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URBAN AIR POLLUTION PROBLEMS

BRIEFING DOCUMENT FOR THE PRESIDENT'S AIR QUALITY ADVISORY BOARD

ENVIRONMENTAL PROTECTION AGENCY

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URBAN AIR POLLUTION PROBLEMS

prepared by the
U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION VII

BRIEFING DOCUMENT

for

THE PRESIDENT'S AIR QUALITY ADVISORY BOARD

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URBAN AIR POLLUTION PROBLEMS

A Briefing Document for

THE PRESIDENT'S
AIR QUALITY ADVISORY BOARD

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With the Assistance of

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INTRODUCTION

This Briefing Document has been prepared for the use of the President's Air Quality Advisory Board in connection with its meeting in St. Louis, Missouri, from March 26-30, 1973.

The topic of Urban Air Pollution Problems was chosen for discussion because over three-fourths of the nation's total population lives and works in urban areas and air pollution is largely, although by no means exclusively, an urban problem. In many cases it is difficult to separate the inner city pollution problem from that of the overall urban area concerned.

This document is an attempt to focus on some of the acute environmental problems faced by urban areas. It is necessarily incomplete and inconclusive because environmental problems in the urban setting cannot be sharply differentiated from nonenvironmental problems. The problem of urban air pollution can be masked or can mask other social problems such as urban transportation, slum housing, inadequate health care, recreation and education and unemployment. Presentations by experts during the first day with attendant questions by the Board should plug gaps in the written information available.

URBAN AIR POLLUTION - ITS CAUSES AND EFFECTS

The major sources of urban air pollution are automobiles, trucks, buses, and aircraft; commercial and residential heating; construction and demolition; incineration; and steam and electric generation. These sources release hydrocarbons, carbon monoxide, nitrogen oxides, sulfur oxides, particulate matter, oxidants, lead, other gaseous by-products and dust. (1) Although the mix and levels of pollutants borne in the air vary from city to city due to differing combinations of effluent emissions and meteorological dispersion patterns, characteristically, greatest concentrations are found either in areas surrounding central commercial districts or in adjacent industrial areas. In these areas the density of sources is greatest.

Health Effects

Air pollution has a number of adverse effects on urban residents. The most important effect is real and potential health damage. For the central city resident, the day-to-day exposure is especially detrimental. Not only is he often in the area of highest concentration, but he is more likely to suffer from other chronic diseases and lack proper medical care.

Numerous studies have been conducted to determine the effects of air pollution on human health. Unsurprisingly, the area most frequently affected is the respiratory system. The cardiac problems associated with air pollution are often indirect effects since decreased lung efficiency

puts a greater strain on the heart as it strives to force the ailing lungs to absorb the minimum required amount of oxygen from the inhaled air.

Studies in Chattanooga, Tennessee (Air Criteria for Oxides of Nitrogen, 1971) and New York City (2), show an increase among adults in bronchitis, coughs, and shortness of breath in areas of high levels of sulfur oxides, particulates, and oxides of nitrogen. In the New York study, the percentage of women with chronic bronchitis in low pollution areas was 4.7 percent as compared with 11.6 percent of the women in high pollution areas. Only 11.5 percent of men in low pollution areas had bronchitis as compared to 18.4 percent of men in high pollution areas. In all cases pollution variables were prime explanatory factors.

Increases in mortality rates as a function of high levels of pollutants have been measured in several studies. (2) In poor urban areas in Chicago, daily respiratory mortality increased as levels of SO_2 increased. (2) The death rate for respiratory disease per 10,000 ranged from 4.3 in low SO_2--high socioeconomic areas to 12.5 in areas of high SO_2--low socioeconomic levels. In this study, the people were poor and predominantly non-white.

Carbon monoxide is probably the most well known automotive pollutant since deaths due to this gas are frequently recorded. The toxicity of carbon monoxide results from its chemical characteristic of attacking the blood's oxygen carrying capacity. Carbon monoxide reacts with the red blood cells 200 times faster than oxygen.

The ambient levels of carbon monoxide commonly found in city air (around 10 ppm) result in individuals living day in and day out, deprived of 2 percent of their blood's oxygen carrying capacity. (3) The urban poor who live and play along city streets are deprived of even more of their blood'x oxygen carrying capacity.

On the city streets where the urban poor live, traffic frequently creates carbon monoxide levels on the order of 100 parts per million. A traffic jam can create levels of several hundred parts per million. The burden of carbon monoxide is further aggravated by the fact that persons with hereditary traits, such as sickle cell anemia, are particularly vulnerable to the effects of carbon monoxide.

Carbon monoxide can cause behavioral changes when blood levels of carbonoxyhemoglobin (COHb) reach 6.6 percent, a level not uncommon in driving or in many work situations.(2) At this level, vigilance may be impaired. A driver may not notice a traffic light or another car beside him and his response to stimulus is slower. The implications for decreased driving safety are obvious.

Lead is another air pollutant which has been known to be toxic to humans for over 2,000 years. Every day, millions of U.S. citizens breathe air which is contaminated to levels exceeding 1.5 ug/m^3, which is the Ambient Air Quality Standard adopted by California. Automobiles emit most of the lead found in urban air (roughly 90 percent). Lead emissions from tailpipes are a by-product of the combustion of leaded gasoline.

It appears that in suburban areas, the concentration of lead in air is approximately 0.1 ug/m^3, while in urban areas the concentration is

approximately 1.0 ug/m^3. A composite figure for the blood lead level of the rural American male is 16 ug/100gm, while the composite figure for the urban American male is 21 ug/100gm; more than 30 percent higher. (3) A similar comparison for females indicates a 60 percent increase with exposure in the urban area. Additional data on the blood lead levels of urban and suburban adults was published in the January 10, 1973 Federal Register.

While lead in gasoline is generally recognized as an environmental hazard, lead in paint is a more immediate problem for the poor. Lead is present in the paint, plaster, and caulking on some older houses and apartments which are now in decaying neighborhoods. Prolonged or recurrent ingestion of this lead, produces abnormal levels of lead in the blood and, in a significant number of cases, lead poisoning. Eighty percent of lead poisoning cases can be traced to lead paint consumption.

Effect on Materials and Climate

In addition to the health effects, air pollution causes other adverse effects on the urban population. These include decreased visibility, weather modification, increased corrosion on buildings, cars, fences, and other property and decreased attractiveness of surroundings due to accumulation of settled particulate matter and increase of corrosion.

The decreased visibility in urban areas resulting from smoke and smog has played a major role in numerous single-car and multiple-car accidents. It is not unusual to read of 30 or more cars being involved in a single accident brought about by a combination of poor visibility due to air pollution and driver carelessness. Pilots operating out of

airports located in the midst of industrial areas report frequently that smoke and smog obscure visibility during take-off and landing to a degree that flight operations can be made dangerous.

There are psychological effects associated with reduced visibility due to air pollution. A Los Angeles study showed that children in school had become more unruly during days of high pollution. (4)

Ultraviolet rays, considered so important to the health of infants and growing children, are greatly reduced in intensity by air pollution. (4)

The corrosiveness of certain air pollutants and to a lesser degree, the erosion caused by particulate matter in motion, take an annual toll in tens of millions of dollars. New York City has spent more than five million dollars on City Hall in Manhattan and Borough Hall in Brooklyn just to repair damage caused by air pollution. Peeling house paint, rusting iron fences, accelerated automobile corrosion, are all mute testimony to the havoc wrought by air pollution.

Air pollution can damage and fade clothing, curtains and other fabrics. Even if not directly disintegrated by air pollutants, fabrics in polluted atmospheres need more frequent washing or cleaning, adding a dollar cost and shortening the life of the fabric.

One of the most intriguing aspects of air pollution is its effect on weather and climate. The introduction of man-made particulate matter into the atmosphere can alter the cloud forming process and precipitation patterns. Table 1 indicates some of the climatic changes caused by the introduction of contaminants into the air.

Social Effects

The urban poor suffer most from the effects of air pollution. A number of reasons can be given for this situation.

1. Landlords in run-down urban areas tend to purchase the cheapest available fuel for space heating. This in conjunction with older, poorly serviced heating equipment, results in a greater discharge of SO_2, particulates, hydrocarbons and carbon monoxide.

2. Automobiles in poorer urban areas are generally older, more decrepit and poorly maintained. Hence, they have much greater carbon monoxide and hydrocarbon emissions than autos owned by the more affluent.

3. Streets are not cleaned as often in poor urban areas, as in more affluent areas. This leaves a greater residue of soot, dust and dirt to be blown about by wind and re-entrained by traffic.

TABLE 1

Climatic Changes Produced by Cities (5)

Element	Comparison with Rural Environs
Contaminants:	
dust particles	10 times more
sulfur dioxide	5 times more
carbon dioxide	10 times more
carbon monoxide	25 times more
Radiation:	
total on horizontal surface	15 to 20% less
ultraviolet, winter	30% less
ultraviolet, summer	5% less

TABLE 1 (continued)

Cloudiness:

clouds	5 to 10% more
fog, winter	100% more
fog, summer	30% more

Precipitation:

amounts	5 to 10% more
days with 0.2 in.	10% more

Temperature:

annual mean	1 to 1.5°F more
winter minima	2 to 3°F more

Relative Hunidity:

annual mean	6% less
winter	2% less
summer	8% less

Wind Speed:

annual mean	20 to 30% less
extreme gusts	10 to 20% less
calms	5 to 20% less

Urban poor tend to live, work, and play in the inner city, thus they spend twenty-four hours a day, nearly everyday, breathing higher air pollution levels. The middle class, on the other hand, lives, works, and/or plays much of the time in the areas where the air is cleaner. They have the financial means to live in the suburbs, or cleaner parts of town, take day trips through the countryside and spend summers at the lake. At the end of a year's time, the urban poor have spent considerable more time breathing polluted air than their more affluent suburban counterparts.

Urbar poor tend to live in row or tenement housing close to street traffic. They breathe the high pollution levels produced by traffic coming into the city in the morning and leaving in the evening. The road in front of an average suburban home carries traffic typified by a car cruising at 25 mph - the lowest pollution traffic mode. The street in front of an average city house carries high traffic counts typified by frequent stops with long idle periods, accelerations and decelerations - all high pollution traffic modes.

People who are afflicted with the poorest environmental quality are least likely to be in the vanguard of those who are complaining. (6) Their needs for greater income and better living facilities probably take precedence over needs for better recreation and cleaner air. If the poor must be concerned about immediate needs, then their environment, the ecology to which they belong, is likely to be housing and work. Very few environmental problems are obviously urgent to all.

DESCRIPTION OF URBAN ST. LOUIS

The St. Louis area was chosen as the focal point for the Board's consideration of air pollution problems because the area presents many of the problems that are typical to other U.S. cities. The City of St. Louis has been involved in air pollution control since the first anti-smoke ordinance was passed in 1893. (7) At present, the City of St. Louis, St. Louis County, the State of Missouri and the State of Illinois are involved in air pollution control in the area.

The City of St. Louis covers an area of 62 square miles with a population of about 622,000 people. (8) The greater metropolitan area of St. Louis includes a number of counties on either side of the Mississippi River with a population of more than 2.3 million.

The terrain of St. Louis is generally flat, possessing gradual undulations rather than sharply defined ridges and valleys. Although there are a few rises and drops of 100 feet in elevation over a short distance, the area within a 25-mile radius of downtown St. Louis is generally free of major orographic features that strongly influence meteorological variables. A flat area known as the American Bottoms, surrounded by a cresent-shaped bluff, lies on the east side of the Mississippi across from St. Louis.

The average elevation of the American Bottoms is about 60 feet below the main commercial area of St. Louis. At times, stagnation of a shallow pool of cool air in this basin during the night enhances radiation fog formation under clear skies in the early summer. Similar conditions

exist through the Missouri River bottom area to the west and north of St. Louis.

The climate of the area is classified "Humid Continental:" springs and autumns are moderate, winters are brisk, summers are hot; the average annual temperature is 56.7°F; the average annual precipitation of 38.91 inches is distributed throughout the year. (7)

Metropolitan areas impose their own effects on the atmosphere and St. Louis is no exception to this rule. The City acts as a heat island, or heat reservoir, by storing up heat by absorption from the sun's rays during the day and releasing the stored heat at night. The average minimum temperatures for each of four months were mapped for several sites in and around St. Louis and it was noted that in each case the minimum temperatures in the downtown area averaged higher than at any of the outlying sites.

In order for a heat island to form, it is important to have haat supplied by absorption of solar radiation, low wind speed to establish thermal stratification and the presence of buildings to reduce wind speeds. The City profile can cause a significant reduction in wind speed relative to the surrounding rural areas, permitting air pollutants to accumulate. With the heat island effect, circulating air rises over the hot center of the City and falls upon the cooler edges, traps pollutants and produces the familiar "dust dome" or "haze hood."

In reviewing the air pollution problem in St. Louis, it is important to consider the sources of the contaminants within the urban area. Land use in the City of St. Louis can be broken down as follows:

1. Residential areas including one, two, three, four and multi-family dwellings and residential garage space - 20.6 square miles.

2. Commercial areas including local businesses, schools, libraries, retail trade service businesses, etc. - 6.8 square miles.

3. Industrial areas including light and heavy industries - 7.2 square miles.

4. Transportation areas including streets and railroads - 17.9 square miles.

5. Non-polluting areas including parks, playgrounds, vacant lots, cemeteries, etc. - 9.7 square miles. (9)

In other words, about 85 percent of the land within the confines of the City contribute in one way or another to the air pollution problem.

The City of St. Louis is unique as far as most American cities are concerned in that there is no room for further expansion. (The corporate limits of St. Louis City were fixed by the Missouri legislature and the City is not a part of St. Louis County.) The City is bounded by the Mississippi River to the east and numerous incorporated communities in the other directions (see Figure 1).

Referring to Figures 2 and 3, it can be seen that the heavy concentrations of both particulates and SO_2, are located along the Mississippi River near the center of the urban area. (10) Because of a heavy concentration of industry to the south and the prevailing southerly winds, the center city area is exposed to much higher concentrations of both pollutants than the outlying suburbs.

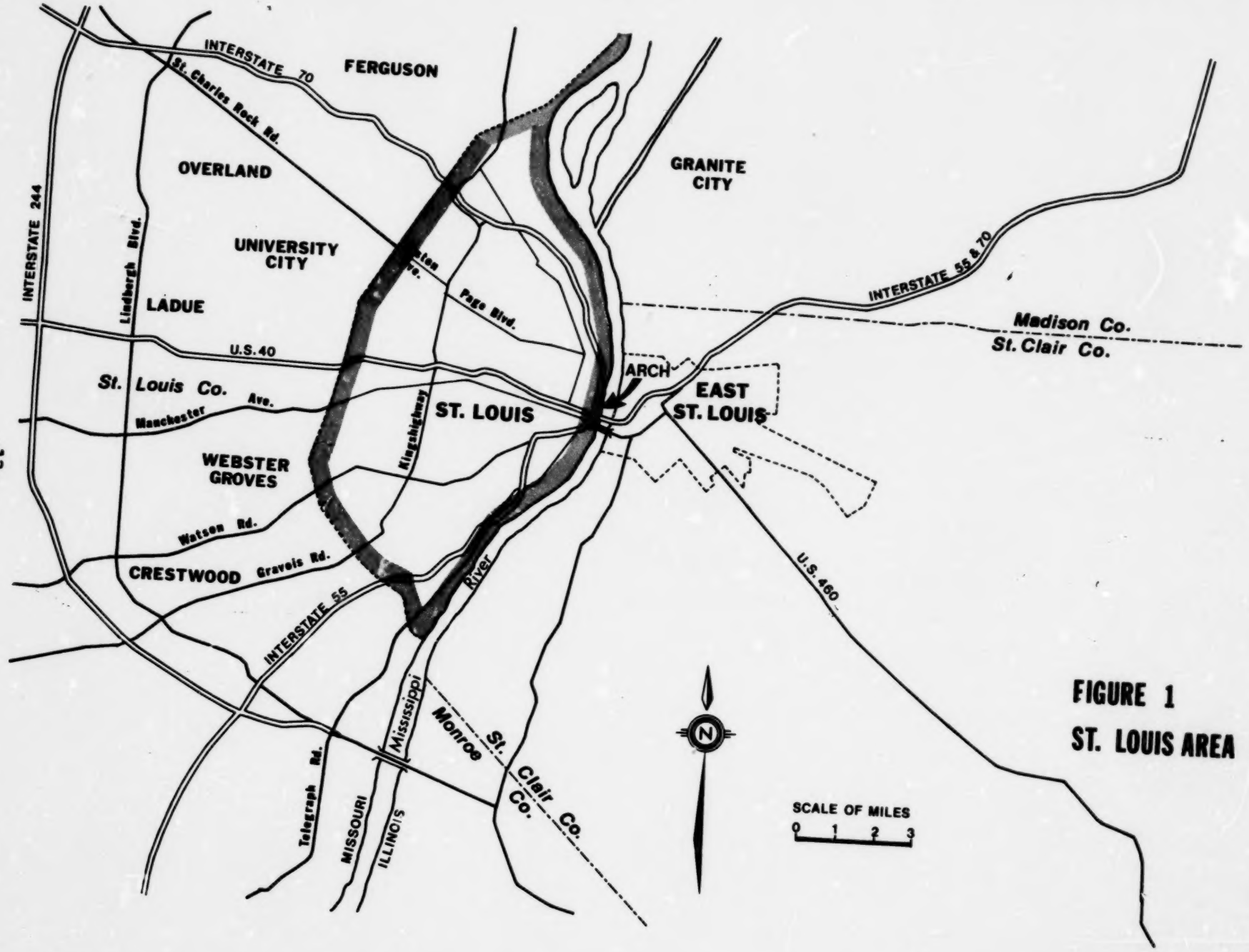

FIGURE 1

ST. LOUIS AREA

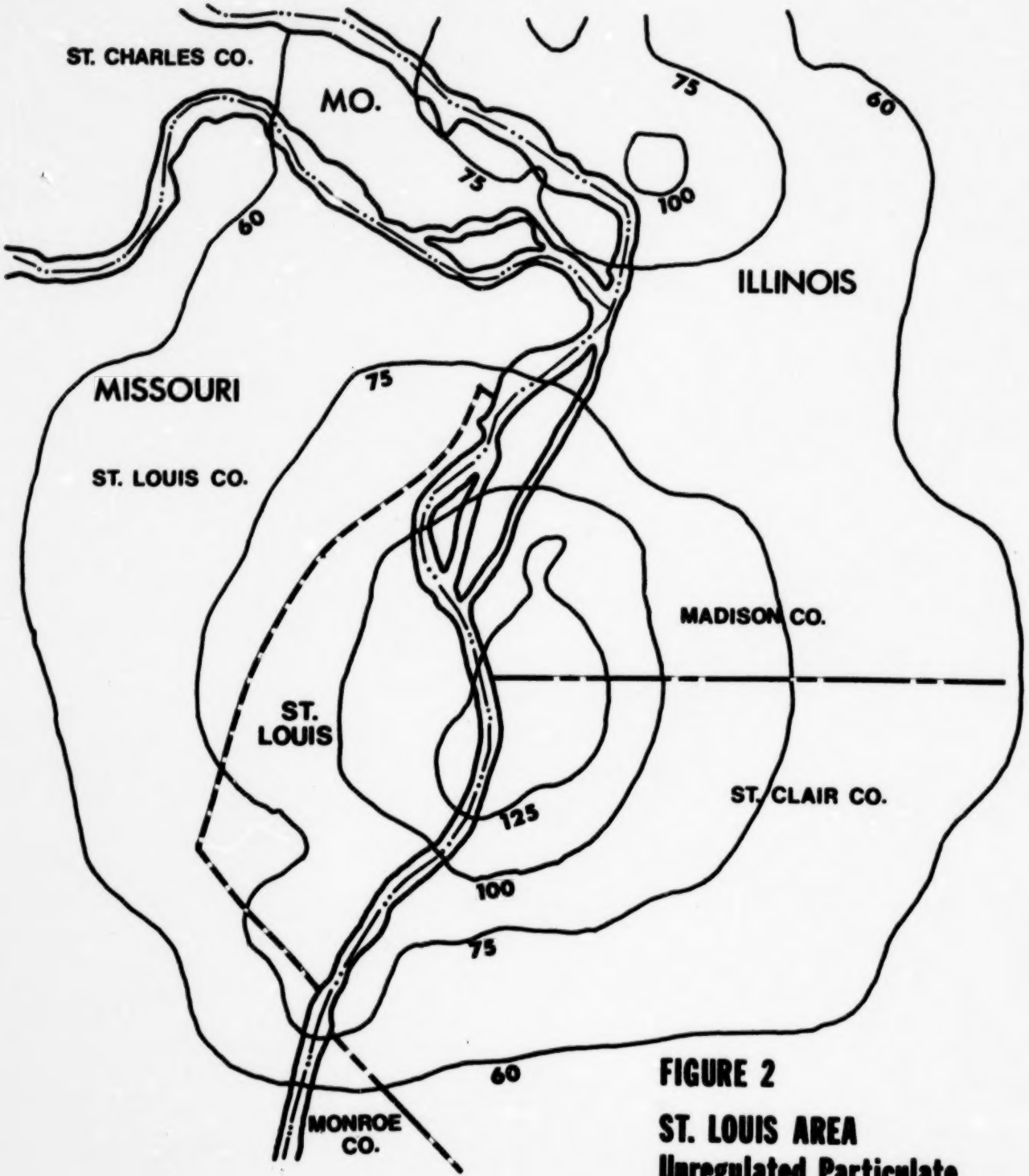

FIGURE 2

ST. LOUIS AREA
Unregulated Particulate Levels (Existing 1968)

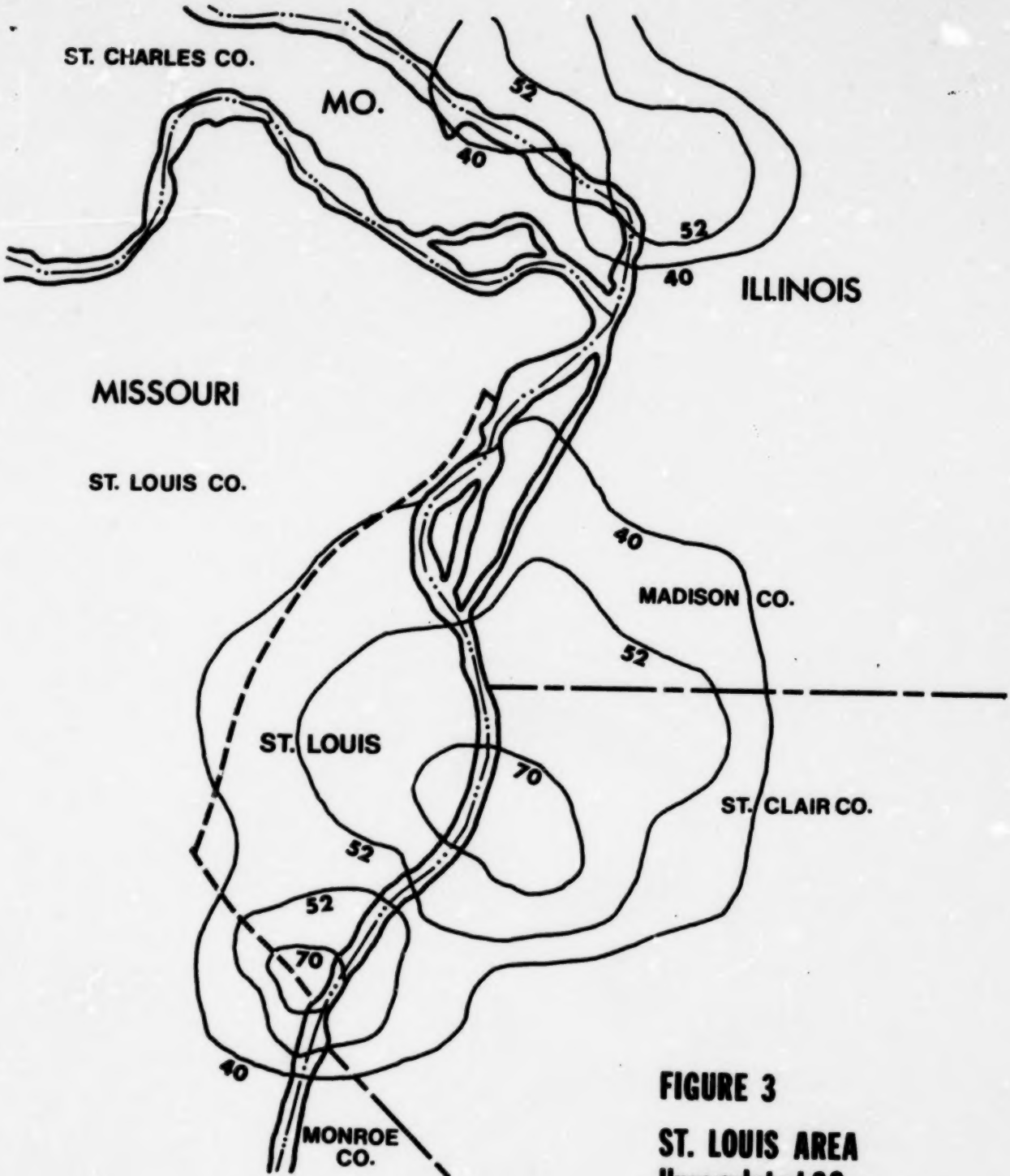

FIGURE 3

ST. LOUIS AREA
Unregulated SO_2
Levels (Existing 1968)

To monitor the future changes in air quality, the St. Louis Air Quality Control Region has expanded its existing air quality system to include eight remote controlled telemetry stations with two additional sites planned. Each station includes the following instrumentation: Sulfur Dioxide Analyzer; Nitrogen Dioxide, Nitric Oxide; Total Hydrocarbons; Carbon Monoxide; and COH. The samples collected are analyzed and the results are stored in a central computer in the City Hall.

A study of the St. Louis area made in 1966 by the National Air Pollution Control Administration reported that suspended particulates, dust fall, and concentrations of sulfur dioxide were higher in the predominantly poor black neighborhoods of St. Louis and East St. Louis than elsewhere in the metropolitan area. Table 2 published in the 1971 CEQ Report, indicates a direct correlation between income level and the pollution level. As the income level rises, the concentrations of particulates and sulfation decrease.

TABLE 2

Air Pollution Exposure Indices by Income (11)

Income	Suspended particulates *	Sulfation **
St. Louis		
0 2,999	91.3	.97
3,000-4,999	85.3	.88
5,000-6,999	79.2	.78
7,000-9,999	75.4	.72
10,000-14,999	73.0	.68
15,000-24,999	68.8	.60
25,000-over	64.9	.52

*micrograms/cubic meter
**miligrams/100 square centimeters/day

Another fact which closely relates to the income level concerns the problems in the neighborhood. In 1963, people living in St. Louis City felt that unemployment, juvenile delinquency and lack of recreation areas were a far more serious problem than air pollution, whereas the residents of suburban Madison and St. Clair County in Illinois, considered air pollution to be one of the most serious problems. (7) A similar relationship could probably be shown to exist in most urban areas.

Results of a similar survey presented by Hodges (12) in January 1973, reflect a change in attitude and an increased awareness of the air pollution problem. Of the ten social problems listed, air pollution was shown to be more serious than any other problem as far as the overall City was concerned. Public transportation and traffic outranked air pollution as serious problems in the immediate neighborhood.

ECONOMICS - COSTS vs BENEFITS

In a large city, the closing down of a single plant would have less severe economic impact than in a smaller city. Theoretically, workers could move from facilities with high pollutant emissions to low polluting ones as long as the required skills were similar. Further, the effects of decreasing capital efficiency and increasing cost of capital will be less severe in low polluting industries since little expenditures for pollution control equipment are required. The economy of the metropolitan area might also support some pollution abatement equipment industries, and therefore experience some economic benefit. Concurrent to the growth in the abatement industry will be growth in the ancilliary service industry.

At this point, a judgement must be made. Will the center city function as part of the metropolitan system? Or, will the effects of pollution control be similar to those of the small town? Physically, the center city is part of the overall metropolitan system. The unskilled worker of the center city tends to resist migration and seeks other local employment. (2) Even if he wanted to migrate and seek work elsewhere in the metropolitan area, it is doubtful whether he could afford it. By living and working within the inner city, a resident saves considerably on transportation costs. This problem may become more acute when considered in the context of the requirements for mobile emission devices on automobiles. The cost of these devices is estimated at 300 dollars per vehicle. (2) A price use of 300 dollars

per automobile becomes a highly regressive tax for the low income center city resident. It is possible that a cost increase of that amount could virtually eliminate the automobile as an alternative means of transportation in the center city.

Speaking at the 52nd Annual Conference of the Highway Research Board at the Sheraton Park Hotel in Washington on January 24, 1973, EPA Administrator William D. Ruckelshaus said, "We have to balance the benefits of achieving healthy air within a certain time frame against the social costs. The benefits are undeniable, but if the price is a severely crippled city, then it may be necessary to stretch out the time for compliance."

It is generally assumed that air pollution tends to depress property values despite the lack of data to substantiate this assumption. In 1970 the National Air Pollution Administration completed an analysis of property values in relation to air pollution in various neighborhoods in Washington, D.C., Kansas City and St. Louis.(13) In each community, a comparison was made of the selling prices of homes in neighborhoods with different levels of sulfur oxides and particulate pollution. Even after allowance was made for other relevant factors, such as size of homes, proximity to schools, and character of the neighborhood, it was found that homes in the areas of higher air pollution levels generally sold for 300 to 500 dollars less.

The aggregate impact of expenditures for air pollution control on the national economy includes effects on the levels of demand and supply of total production and on prices, employment and economic growth. Some

of these prices will be reflected in higher consumer prices.

The largest increase in consumer prices is projected for transportation. (14) The 4.3 percent projected increase in transportation prices is primarily due to the increase in motor vehicle prices, but to some extent also due to higher electricity, iron and steel and aluminum prices.

The actual cost of the air pollution burden on the urban dwellers is incalculable. Some specific costs can be measured - the cost of commercial laundering, cleaning, and dyeing of fabrics soiled by air pollution is about 800 million dollars a year. (15) The cost of washing cars dirtied by air pollution is about 240 million dollars a year. (15)

Air pollution also imposed many other costs which cannot be measured. Among them:

- Hospital bills, doctor bills, and medicines for people made sick by air pollution.
- Time lost from work by those incapacitated by air pollution.
- Added maintenance and painting of buildings and homes.
- Damaged equipment, materials and fabrics.
- Injuries and property damage caused by reduced visibility.
- Burning lights in cities darkened by air pollution.

A study in New York City has estimated that air pollution could impose costs of up to 850 dollars a year on each family living there for extra cleaning household maintenance and personal care.

On the national scale, the 1972 CEQ Report (16) suggests that direct job loss attributable to environmental regulations in the affected

industry activities examined may range from 50,000 to 125,000 jobs over the 1972-76 period. These figures represent approximately 1 percent to 4 percent of total employment in the industry activities studied.

In the 21 months through last September, according to the latest EPA data, there were only 29 shutdowns of industrial establishments throughout the country in which environmental costs were mentioned as even a contributing factor. (17) The 29 shutdowns involved 7,013 jobs which represent less than two-tenths of 1 percent of total national unemployment.

Unemployment as a result of meeting the air quality standards does not appear to be a serious problem in the St. Louis area. (18) According to local authorities, only one foundry has closed as a result of air pollution requirements. This foundry has since been sold; the necessary controls were installed and it is now in operation again.

An additional problem which could result, although there is no data to substantiate the assumption, concerns fuel conversions. Many plants in St. Louis have switched or cut back on the use of coal; therefore, the demand for skilled boiler firers has declined.

In considering the economic impact of air pollution control, it is important to compare the direct and indirect costs of control with the direct and indirect costs of the damage which could be mitigated by such control.

A report issued by the U.S. Public Health Service entitled "The Cost of Air Pollution Damages: A Status Report," (14) estimates that in 1977, the direct costs of human mortality and morbidity due to only

two pollutants, sulfur oxides and particulates, will total 9.3 billion dollars, with an additional damage estimate to property values of around 8 billion dollars annually, and materials and vegetation of around 8 billion dollars. The total annual damage cost is about 25 billion dollars. The effects of the air pollutants discharged by automobiles (HC, CO, NO_x, and indirectly, O_3) are not covered in the report because of an almost complete lack of data on which to base any estimates.

If reductions in damage are equated to benefits, then it is possible to compute a crude estimate of the value of benefits obtained from the emission reductions summarized in Table 3. Table 4 gives the projected national annual benefits (damage cost reduction) attributable to these emission reductions in Fiscal 1977. With the assumptions made, the total computed benefits in 1977 of 14.2 billion dollars are generated by the 12.3 billion dollars estimated to be spent in that year for emission control, a benefit/cost of over one to one. When it is considered that due to lack of data, the value of health benefits generated by reductions in CO, O_x, and NO_x have not been included in Table 3, even though the costs of control for these pollutants are included in the 12.3 billion total annual control cost in Table 4, then the one to one benefit/cost ratio appears conservative.

While the above figures represent national totals, it is reasonable to assume that the major portion of these benefits will be for the urban population.

TABLE 3 - NATIONAL EMISSION REDUCTIONS AND COSTS UNDER ASSUMED STANDARDS FOR FISCAL YEAR 1977
(COSTS IN 1970 DOLLARS (14))

Source Class Type	Emission Level without further control[2] (Thousands of Tons Per Year)					Emission Reductions and Costs Under Assumed Standards: Decrease of Emission Level (Percent)[2]					Total Control Cost (Millions of Dollars in FY 77)[3]	
	Part	SO_x	CO	HC	NO_x	Part [4]	SO_x [4]	CO	HC	NO_x	Investment	Annual
Mobile Sources	450	1,490	165,000	28,000	9,900			66	72	44	$ [7]	$ 8,385 [7]
Solid Waste Disposal	1,830	260	6,720	2,530	510	96	0	92	86	0	$ 472	$ 224
Stationary Fuel Combustion:												
Small & intermediate boilers	2,330	7,660	---	---	4,800	84	83	---	---	0	$ 879	$ 1,116
Steam-electric-power	5,600	27,600	---	---	6,000	49	90	---	---	0	$ 4,660	$ 1,360
TOTAL	7,930	35,260	---	---	10,800	72	88	---	---	0	$ 5,539	$ 2,476
Industrial Process Studied:												
Asphalt Patching	403	---	---	---	---	86	---	---	---	---	$ 272	$ 63
Cement	908	---	---	---	---	93	---	---	---	---	$ 89	$ 35
Coal Cleaning	342	---	---	---	---	97	---	---	---	---	$ 21	$ 9
Grain Plants: Handling	1,430	---	---	---	---	93	---	---	---	---	$ 395	$ 83
Feed	362	---	---	---	---	94	---	---	---	---	$ 19	$ 4
Gray Iron Foundries	260	---	3,800	---	---	88	---	94	---	---	$ 348	$ 126
Iron and Steel	1,991	---	---	---	---	96	---	---	---	---	$ 841	$ 306
Kraft (Sulfate) Pulp	536	---	---	---	---	85	---	---	---	---	$ 132	$ 40
Lime	609	---	---	---	---	94	---	---	---	---	$ 29	$ 7
Nitric Acid	---	---	---	---	230	---	---	---	---	89	$ 37	$ 14
Petroleum Products & Storage	---	---	---	1,349	---	---	---	---	78	---	$	$
Petroleum Refineries	241	3,010	12,100	197	---	59	99	99	94	---	$ 378	$ 73
Phosphate	350	---	---	---	---	54	---	---	---	---	$ 31	$ 15
Primary Nonferrous Metallurgy:												
Copper	314	3,335	---	---	---	9	84	---	---	---	$ 313	$ 100
Lead	39	213	---	---	---	33	86	---	---	---	$ 65	$ 16
Zinc	71	555	---	---	---	0	75	---	---	---	$ 41	$ 18
Aluminum	49	---	---	---	---	89	---	---	---	---	$ 923	$ 256

TABLE 3 - NATIONAL EMISSION REDUCTIONS AND COSTS UNDER ASSUMED STANDARDS FOR FISCAL YEAR 1977
(COSTS IN 1970 DOLLARS (14))

Source Class Type	Emission Level without further control 2/ (Thousands of Tons Per Year)					Emission Reductions and Costs Under Assumed Standards						
						Decrease of Emission Level (Percent) 2/					Total Control Cost (Millions of Dollars in FY 77) 3/	
	Part	SO_x	CO	HC	NO_x	Part 4/	SO_x 4/	CO	HC	NO_x	Investment	Annual
Secondary Nonferrous Metallurgy	34	---	---	---	---	83	---	---	---	---	$ 32	$ 9
Sulfuric Acid	38	920	---	---	---	74	81	---	---	---	$ 169	$ 39
TOTAL	7,977	8,033	15,900	1,546	230	86	89	98	80	89	$ 4,135	$ 1,213
Industries Not Studies	10,150	1,530	9,750	1,610	---	0	0	0	0	0	0	0
Miscellaneous Sources Not Studied 5/	7,940	280	19,740	7,750	5,250	0	0	0	0	0	0	0
National Total 6/	36,280	46,850	217,110	41,440	26,690	39	81	57	17	60	$10,146	$12,298

FOOTNOTES:

1/ Assumed standards given in Appendix. Blanks in the table indicate that emission levels meet applicable regulations or that emissions are negligible or do not exist.

2/ Emission abbreviations are: particulates (Part), sulfur oxides (SO_x), carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NO_x).

3/ Projected costs are the initial investment expenditures for purchasing and installing control equipment (total investment) and the continuing annual costs for interest, property taxes, insurance, depreciation, etc., and for operating and maintaining of equipment (ultimate annual cost). Cost of government programs is not included.

4/ Includes light duty and heavy duty road vehicles only. Control of particulate and sulfur oxides from mobile sources was not considered in this study.

5/ Forest fires, structural fires, solvent evaporation, agriculture burning, natural gas production and transmission, coal refining, etc.

6/ To nearest 10,000 tons.

7/ All mobile source emission control investment costs are assumed to be expended in Fiscal 1977. Annual costs are based on Alternative 1 in Table A-5 for meeting 1975 and 1976 vehicle emission standards.

TABLE 4

PROJECTED NATIONAL ANNUAL BENEFITS (DAMAGE COST REDUCTION)(14)
BY SOURCE CLASS IN FISCAL 1977
(1970 DOLLARS IN MILLIONS)

SOURCE CLASS	BENEFIT CLASS			TOTAL BENEFIT	CONTROL COST (Table 1-1)
	Health	Residential Property	Materials and Vegetation		
Mobile	1/	1/	$ 945	$ 945 1/	$ 8,385 3/
Solid Waste	172	145	119	436	224
Stationary Fuel Combustion	3,812 2/	3,267	2,366	9,445	2,476
Industrial Processes Studied	1,413	1,302	734	3,350	1,213
Industries Not Studied	0	0	0	0	0
Miscellaneous 4/	0	0	0	0	0
TOTAL BENEFIT 4/	$5,397	$4,615	$4,164	$14,176	$12,298

1/ Value of benefits from reducing CO, NO_x, and HC emissions not available due to lack of data.

2/ Health damage cost due to NO_x, from stationary fuel combustion not included due to lack of data.

3/ Based on Alternative 1 in Table A-5 for meeting the 1975 and 1976 vehicle emission standards.

4/ Benefit computation based on proportional reduction of damage costs in Table A-6 excluding "miscellaneous" source damage costs since these are generally not controllable and, therefore, cannot become benefits.

FEDERAL ACTIVITIES IN URBAN AREAS

The Environmental Protection Agency is attacking the urban air pollution problem through implementation of the nationwide program set forth under the Clean Air Act of 1970. Achievement of the Primary and Secondary Ambient Air Quality Standards promulgated by EPA for sulfur oxides, particulate matter, carbon monoxide, photochemical oxidants, nitrogen oxides and hydrocarbons should protect the inner-city residents from these contaminants.

The basic vehicle for attaining the Ambient Air Standards is the State Implementation Plans. In these Plans, the States must formulate control strategies which will result in attainment and maintenance of the National Ambient Air Quality Standards. Figures 1 and 2 indicated the 1968 air quality levels in St. Louis for particulates and SO_2 without controls. Figures 4 and 5 show the levels that should be achieved by 1975 with the application of a Missouri and Illinois control strategy. These new levels of air pollution will provide a safer, healthier environment for the urban residents to live and work in.

In St. Louis, it is expected that the Ambient Standards for CO, NO_x, HC and oxidants can be met by the imposition of emission controls on stationary sources of pollution and the decrease in pollution due to increasingly stringent Federal emission standards for new cars. As a result, the St. Louis Region will not be required to develop a strategy for transportation controls.

In other major metropolitan areas, land use and transportation controls will be required to meet the Standards by 1975. Several

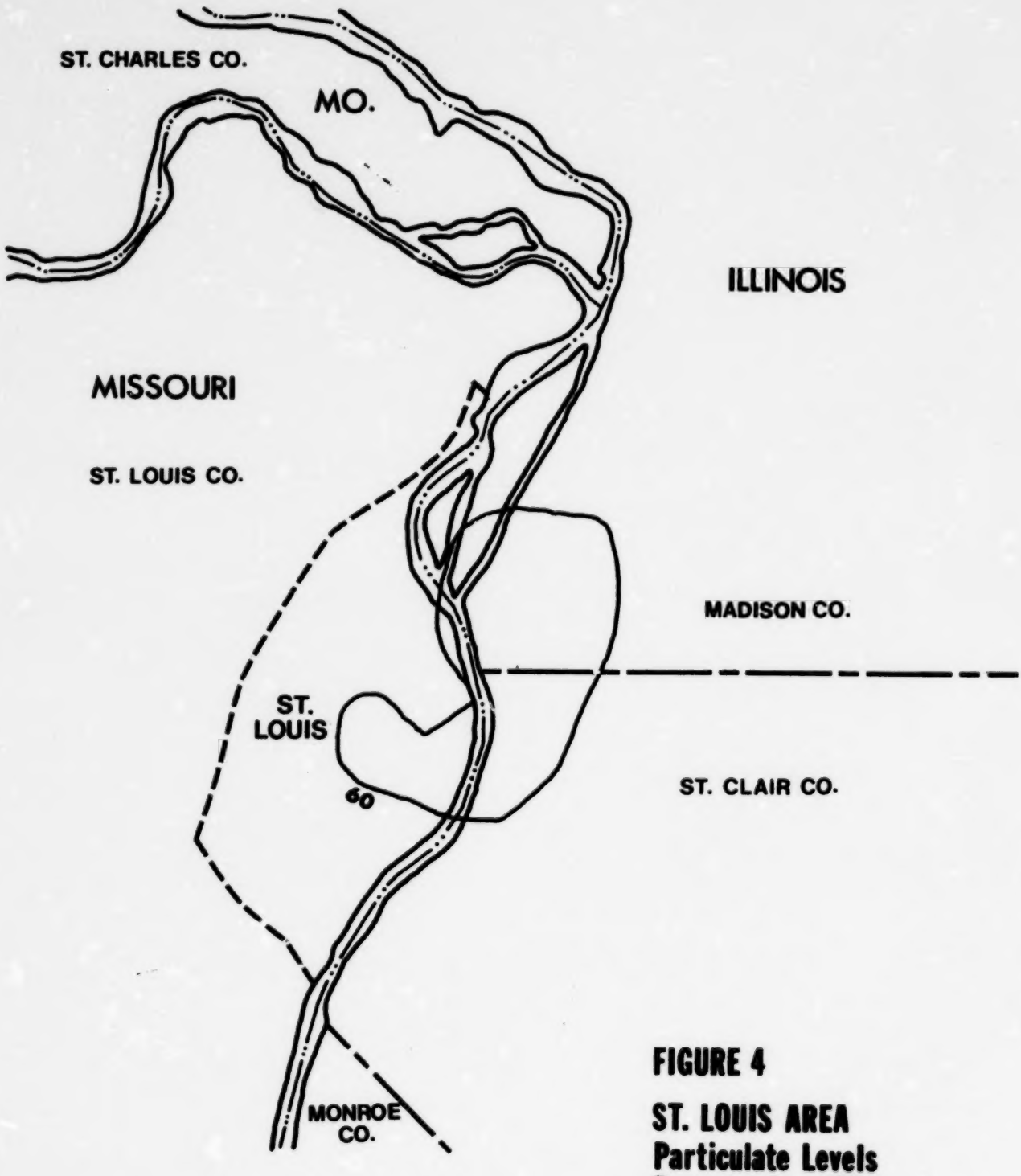

FIGURE 4

ST. LOUIS AREA
Particulate Levels
Forecast for 1975

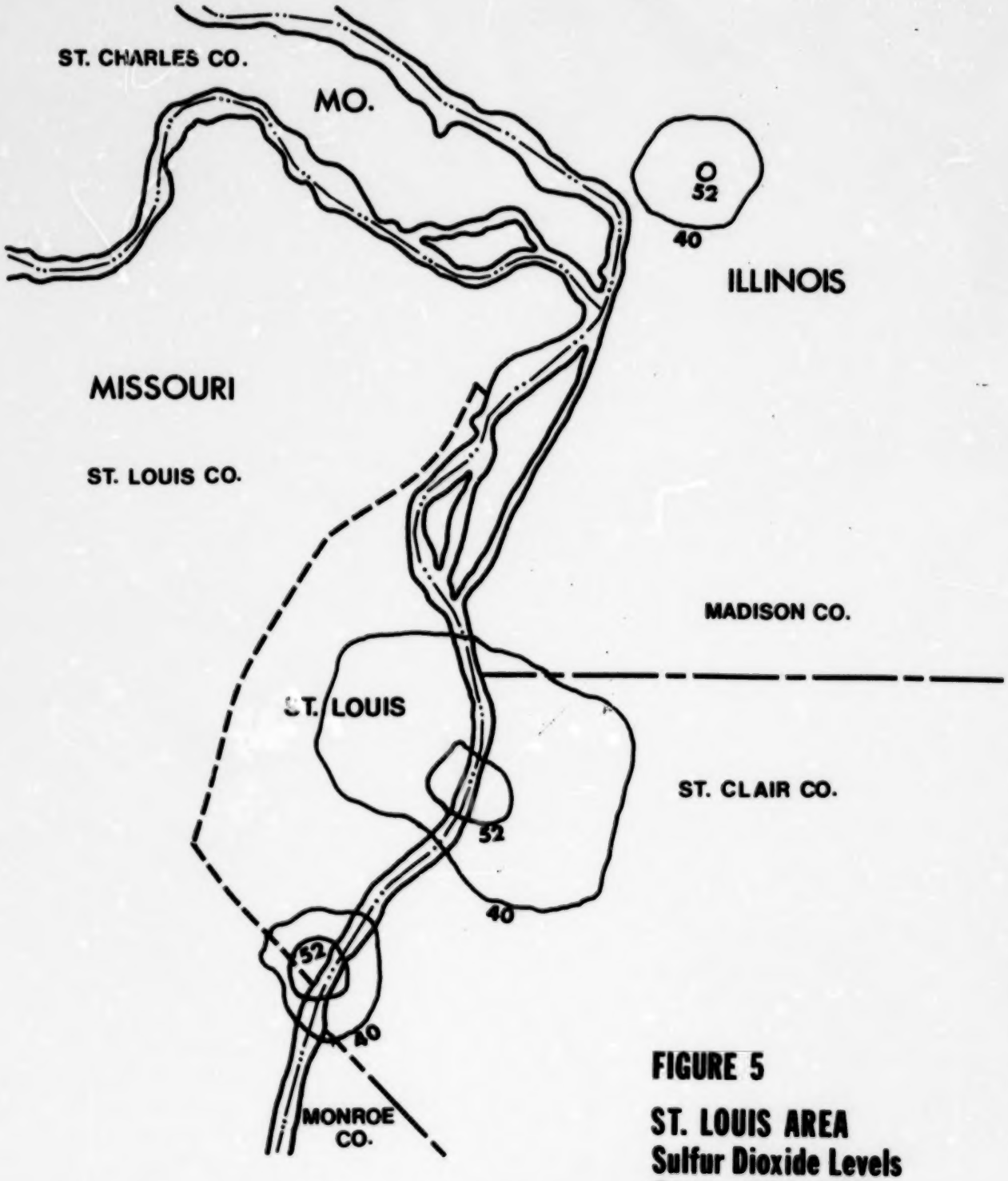

FIGURE 5

ST. LOUIS AREA
Sulfur Dioxide Levels
Forecast for 1975

alternatives are available in each case.

Transportation

There are seven broad categories in which urban air pollution can be reduced or the effects minimized.

1. Reduction of vehicle miles traveled.
2. Increased use of public transportation.
3. Installation of pollution control devices on vehicles.
4. Conversion to less polluting engines (i.e., diesel, gas turbine, electric, etc.).
5. Usage of less polluting fuels (i.e., LPG, NG, etc.).
6. Highway and street planning designed to reduce total emissions and also minimize effects of emissions.
7. Staggered working hours.

It is important to examine how each of the seven aforementioned methods can serve to reduce pollution from mobile sources.

A. Reduction of vehicle miles traveled. There are at least seven ways in which we can reduce vehicle miles traveled. These are:

1. Pollution tax based on an estimate of the quantity of effluents emitted.
2. Wheel tax that would place a fee on any privately owned vehicle in proportion to the number of wheels. Motorcycles would pay the least and large trucks would pay the most.
3. Gas rationing. In cities where mobile sources of pollution represented endangerment to health, this method could be employed

and, in fact, has been recommended by the Administrator of the Environmental Protection Agency for the greater Los Angeles area. Mr. Ruckelshaus has recommended an 82 percent reduction in vehicle miles traveled as being the only short-range solution to the smog problem of this area.

In announcing the proposed transportation controls to lower air pollution levels in the Los Angeles area, Mr. Ruckelshaus said he recognized the economic and social disruptions that could result from the proposed plan, including the direct costs to automobile owners, the possible loss of income to individuals missing work because of inadequate transportation, the impact on service and retail establishments and the entire transportation system.

4. Auto-free zones which would generally include the heart of those urban areas where truck traffic is most dense. High truck density virtually assures slow moving bumper-to-bumper traffic which greatly increases emissions.
5. Parking limitations which could have almost the same effect as an auto-free zone. If people can't park their cars in a certain area except in the high-cost parking lots of many urban areas, they often won't use them.
6. Car-pooling which could conceivably reduce automobile traffic by a factor of as much as four or five.
7. Improved traffic flow which would result from wider streets, traffic light synchronization, reducing the number of two-way

streets, reduced parking areas, etc.

B. Any substantial reduction of VMT would almost undoubtedly result in a corresponding increase in the use of public transportation. The methods available to make the use of public transportation more attractive are:

1. Improving bus service by minimizing passenger waiting time during peak hours, having express buses that make only a few stops, designating exclusive bus lanes, making buses as confortable as possible by minimizing noise, providing air conditioning, etc., and by keeping fares as low as possible.
2. Providing peripheral parking close to bus and train terminals and stations in outlying suburban areas.
3. Offering one price "park and ride" systems that cover the cost of parking and using an adjacent public conveyance. One month trip booklets could be purchased at a much lower average fee per trip than if purchased on a daily basis.
4. Subsidizing a transit system would probably provide the fastest transportation to and from urban areas. The initial cost of a subway would, of course, be very high, but it would probably provide the best means of alleviating urban traffic congestion.

C. By far, the greatest advances to date in reducing air pollution from mobile sources has been in the field of pollution control devices on cars. Beginning in 1968 and continuing until 1976, increasingly sophisticated equipment has been and will be installed to reduce the "big 3" of automotive pollution: HC, CO, and NO_2. Hopefully, that

equipment installed by 1976 will be sufficient to provide the goal of reducing automotive emissions by 90 percent as compared to emissions from automobiles built in 1970.

D. Much research has been conducted in the last 13 years on developing feasible alternatives to the reciprocating spark-ignition engine. The gas turbine, the rotary engine, the steam engine and the battery-powered automobile have all been considered as possible alternatives and all show promise of being potentially capable of providing great reductions in auto emissions without requiring the complex and fairly expensive emission controls required for the spark-ignition engine. Each one of these alternatives presently has one or more disadvantages which must be overcome or eliminated in order that they receive widespread use in the near future.

E. Less polluting fuels, such as liquified petroleum gas (LPG) and natural gas (NG) are possible alternatives to gasoline. Estimates of cost of conversion from gasoline to LPG and NG run between 300 and 700 dollars per vehicle. Since a gas shortage currently exists in the United States, the continued supply of these fuels is questionable and the price of LPG and NG is likely to climb should these fuels be widely adopted for automobile use.

In an effort to minimize automotive lead pollution, a regulation has been adopted requiring every gasoline dispenser to have either a low-lead or no-lead gasoline available. The regulation was published in the Federal Register on January 10, 1973. Automobile manufacturers have responded by greatly reducing the compression ratios of their

engines to eliminate or minimize an engine's need for high octane leaded gasolines.

F. Highway and street planning that can provide good access to and from commercial and industrial centers will reduce traveling time which, in turn, reduces automotive and bus emissions.

G. Staggering work hours in concentrated commercial and industrial areas can relieve transportation congestion which causes cars and buses to idle longer, thereby causing greater transportation emissions. By staggering work hours, you also have the advantage of reducing the intense concentration of pollutants during what is referred to as the "peak hours" of 7 to 9 in the morning and 4 to 6 in the evening.

Land Use

One method of attacking the urban air pollution problem is through the effective use of land. The effects of air pollution can be minimized through the distribution of industries, power plants, incinerators and other stationary sources in such a way as to avoid high concentrations of pollutants in certain urban areas. Land use planning can influence the quantity, quality and spatial distribution of pollution sources by taking into account such factors as topography, meteorology and background air pollution level. (19)

It has been traditional for city planners to use open space to beautify cities and provide recreational areas for adults and children alike in the heart of an urban area. Parks, zoos, playgrounds and botanical gardens have frequently been used for this purpose. This

technique is even more useful today since open areas tend to diminish the impact of air pollution in several ways.

Greenery absorbs moisture and cools by evaporation, creating a cooler, more humid climate than stone and exposed soil. Temperatures over grassy surfaces on sunny summer days are 10 to 14 degrees cooler than over exposed soil. (20)

The President recently called for a major expansion of open space programs focusing on urban area parks. He called for an HUD program of grants to cities and States to develop open space with budget authority increased from 75 million to 200 million dollars.

Mr. Nixon also proposed changes in the Internal Revenue Code to encourage charitable land transfers for conservation purposes and conversion of surplus Federal property to public park use. (21)

There is a continuing need to monitor the health impact of air and other environmental pollution. The Environmental Protection Agency Community Health and Environmental Surveillance Study (CHESS) is now under way in seven metropolitan areas, including St. Louis. The CHESS investigations seek to quantify close-response effects of existing air pollution upon asthma, acute respiratory disease, chronic respiratory disease, heart disease, cancer, lung function, irritation symptoms, death rates, and other health indices. Both the acute and chronic effects of short-term and long-term air pollution exposure will be evaluated. CHESS will also quantify the benefits of pollution control in these areas.

Another important EPA study which is getting underway in St. Louis is the Regional Air Pollution Study (RAPS). The overall objective of the

RAPS program is the development of mathematical simulation models of air pollution processes. Some of the more important considerations in the program include information relating the costs of air pollution controls to benefits to be realized from the achievement of air quality standards. This includes evaluating the effect of air pollution on human social behavior.

People tend to modify life syles and other aspects of behavior as a result of the atmospheric environment and the level of pollution is one factor of that environment. Depending on a wage earner's skills, he may move into a community that is subject to petroleum processing fumes. Another may move to a rural area to avoid air pollution. An individual who chooses to live in a polluted area to avoid commuting costs may be faced with the cost of air filters or purifiers in his home. As thousands of residents are affected by air quality, such costs may add up to major changes in community economy and in the failure or relocation of entire industries. With the completion of this study, the impact of air pollution on the social and economic behavior of urban residents can better be evaluated.

EPA proposed limitations of lead and phosphorous in fuel in the Federal Register on January 10, 1973. Lead in gasoline would be limited to 2.0 grams/gal by January 1, 1975, and gradually cut to 1.5 grams/gal after January 1977. In the same Federal Register, an EPA regulation became effective requiring that every owner or operator of a retail outlet at which 200,000 or more gallons of gasoline were sold during any calendar year beginning with 1971, shall offer for sale at least one

grade of lead-free and phosphorous-free gasoline. Unleaded gasoline is defined as containing less than 0.05 grams/gal lead; phosphorous-free gasoline is defined as containing less than 0.005 grams/gal phosphorous.

Agencies other than EPA are also considering regulations that will help relieve the urban air pollution problem. The Department of Housing and Urban Development (HUD) is now considering regulations to encourage improved land utilization patterns for housing. The regulations would prohibit HUD support for construction of new housing units in the areas and on sites having unacceptable air pollution exposures.

The 1970 Federal-Aid Highway Act required the Secretary of the Department of Transportation to promulgate guidelines designed to ensure that new highways will be consistent with a State's Air Quality Implementation Plan. These guidelines will enable planners to predict and to minimize the air quality impact of a proposed roadway.

On January 1, 1970, President Nixon signed the National Environmental Policy Act of 1969 which established a national policy on the environment. The act requires each Federal agency to prepare a statement of environmental impact in advance of each major action that may significantly affect the quality of the human environment. The agency preparing the statement must consider comments from interested persons and groups as to the potential environmental impact and the agency must present alternatives to the proposed action.

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APPENDIX A[14]

I. INTRODUCTION

Under the Clean Air Act, as amended in 1970, air quality standards have been established for the whole country. Each State is required to adopt and to submit implementation plans to the Administrator of the Environmental Protection Agency for the emission reduction strategy and enforcement thereof to achieve national standards for particulates, sulfur oxides, nitrogen oxides, hydrocarbons, and carbon monoxide.

For this report, uniform emission standards were selected without going through the various steps of emission inventories and diffusion calculations to determine acceptable emission standards for achieving air quality standards in each air quality control region. The basis for the selections was the sample limitation procedures promulgated in the Federal Register, Volume 36, Number 158, Part II, "Requirements for Preparation, Adoption, and Submittal of Implementation Plans," August 14, 1971 (40 C.F.R. 51).

Newly constructed and modified sources are subject to national standards of performance based on adequately demonstrated control technology in accordance with section 111 of the Clean Air Act, as amended. In this report, steam-electric power plants, nitric and sulfuric acid plants, cement plants, and municipal incinerators scheduled for construction after January 1, 1972, were assumed to be subject to national standards of performance promulgated in the Federal Register, Volume 36, Number 159, "National Standards of Performance for Stationary Sources," August 17, 1971.

II. STATIONARY

A. Standards for Particulates

For industrial processes, the process weight rate regulations (Table A-1) are the bases of control cost estimates. These regulations limit the weight of particulate emissions per hour as a function of the total weight of raw materials introduced into a process operation. For sulfuric acid plants, the allowable mist emission is 0.5 pounds per ton of acid produced; for incinerators, the particulates are limited to 0.10 pounds per 100 pounds of refuse charged; for fuel-burning equipment, the particulates are limited to 0.10 pounds per million B.t.u. of heat input. Limitations for incinerators and for fuel-burning equipment are based on the source test method for stationary sources of particulate emission published by EPA in 40 CFR-Part 60, December 22, 1971, Federal Register.

B. Standards for Sulfur Oxides

For fuel-burning equipment, cost estimates are based on mass emission rate of 1.50 pounds of sulfur dioxide per million B.t.u. input. This limit is approximately equivalent to a sulfur content of 1.0 percent by weight in coal and 1.4 percent by weight in oil. For sulfuric acid plants, a mass rate of 6.5 pounds of sulfur dioxide per ton of acid is used for existing sources. Primary copper, lead, and zinc smelters are assumed to limit sulfur oxide emissions to 10 percent of sulfur (measured as sulfur dioxide) in the ore. Sulfur recovery plants at refineries are limited to 0.01 pounds of sulfur emissions per pound of input sulfur.

C. Standards for Carbon Monoxide

Cost estimates were based on treatment of all exhaust gases to reduce the weight of carbon monoxide emission by at least 95 percent.

D. Standards for Hydrocarbons

For industrial processes, cost estimates were based on treatment of all exhaust gases to remove organic material by 90 percent (or more) by weight. For petroleum products storage, it was assumed that all stationary tanks, reservoirs, and containers with more than a 40,000-gallon capacity and with a vapor pressure of 1.5 pounds per square inch absolute (or greater) must be equipped with floating roofs, vapor recovery systems, or other equally efficient devices. In addition, it was assumed that submerged filling inlets must be installed on all gasoline storage tanks with a capacity of 250 gallons or more.

E. Standards for Nitrogen Oxides

No specific cost estimates were made pertinent to the reduction of nitrogen oxides. Limestone injection scrubbing, assumed for power plants, can reduce some oxides of nitrogen by 20 percent. Existing nitric acid plants are restricted to 5.5 pounds of nitrogen oxide per ton of acid produced.

III. MOBILE SOURCES

Table A-2 summarizes the current and projected emission control requirements for reducing hydrocarbons, carbon monoxide, and nitrogen oxides emissions from passenger cars and light duty trucks through Fiscal '77. This table is based on information available through August 15, 1971. Table A-3 shows possible emission control requirements for reducing the same pollutants for heavy duty trucks through Fiscal '77. The assumed standards no longer include particulates. This change was

brought about by the assumption that unleaded or low lead gasoline will be in widespread use during the next 5 years; removal of lead reduces particulates from gasoline engines by 75 to 80 percent (by weight).

Table A-4 provides the reports and estimates of motor vehicle production that served as a basis for cost estimates.

TABLE A-1. ALLOWABLE RATE OF PARTICULATE EMISSIONS BASED ON PROCESS WEIGHT RATE*

Process Weight Rate (lbs/hr)	Emission Rate (lbs/hr)
50	0.30
100	0.55
500	1.53
1,000	2.25
5,000	6.34
10,000	9.73
20,000	14.99
60,000	29.60
80,000	31.19
120,000	33.28
160,000	34.85
200,000	36.11
400,000	40.35
1,000,000	46.72

* To interpolate the data for the process weight rates up to 60,000 lbs/hr, the equation

$$E = 3.59P^{0.62} \qquad P \leq 30 \text{ tons/hr};$$

To interpolate and extrapolate in excess of 60,000 lbs/hr, the equation

$$E = 17.31P^{0.16} \qquad P > 30 \text{ tons/hr}$$

where E is emissions in pounds per hour, and p is process weight rate in tons per hour.

TABLE A-2. CURRENT AND PROJECTED EMISSION CONTROL EQUIREMENTS FOR AUTOMOBILES AND LIGHT TRUCKS (6000 LB. GVW OR LESS)

Model Year	Test Procedure[a]	Exhaust Emissions, Gm/Mi			Evaporation Gm/Test	Assembly Line Test
		HC	CO	NO_x		
1968[b]	FTP	(275 ppm)	(1.5 vol.%)	NR	NR	NR
1969[b]	FTP	(275 ppm)	(1.5 vol.%)	NR	NR	NR
1970	FTP	2.2	23	NR	NR	NR
1971	FTP	2.2	23	NR	6	NR
1972	CVS	3.4[c]	39[c]	NR	2	NR
1973	CVS	3.4	39	3.0	2	[d]
1974	CVS	3.4	39	3.0	2	[d]
1975[e]	CVS	0.41	3.4	3.1	2	[d]
1976[e]	CVS	0.41	3.4	0.4	2	[d]
1977[e]	CVS	0.41	3.4	0.4	2	[d]

Notes:

NR - No Requirement

GVW - Gross Vehicle Weight

[a] - Federal Test Procedure (FTP), 7-mode cycle.
- Constant Volume Sampler (CVS) using 1372 second driving cycle.

[b] - Standards for 1968 and 1969 are expressed as parts per million (ppm) or volume percent.

[c] - The larger numbers for HC and CO standards beginning 1972 are due to the fact that the CVS procedure gives larger readings than FTP. On an equal test procedure 1972 standards are more stringent than 1971 and do not represent a relaxation of previous requirements.

[d] - Assumes federal requirement for test on 3 percent of nationwide sales expected starting 1973, using a new short test cycle now under development.

[e] - Definition of standards was published by EPA on 7-2-71. A hot start cycle is added to the procedure beginning MY 1975.

TABLE A-3. CURRENT AND POSSIBLE* EMISSION CONTROL REQUIREMENTS
HEAVY DUTY VEHICLES (OVER 6000 LB. GVW)

GASOLINE ENGINES

Model Year	Test Procedure[a]	Exhaust Emissions [b] Concentration-ppm or % HC	CO	Mass-gm/bhp hr HC+NOx	CO	Evaporation Grams/Test
		ppm	Vol. %			
1967-69	NR	NR	NR			NR
1970-71	Eng. Dyn.	275	1.5			NR
1972	Eng. Dyn.	275	1.5			NR
1973-74	Eng. Dyn.	275	1.5			10
1975-77	Eng. Dyn.			5	25	10

DIESEL ENGINES

Model Year	Test Procedure[d]	Exhaust Emissions Mass-gm/bhp hr HC+NOx	CO	Smoke %Obscure[e]
1967-69	---	NR	NR	NR
1970-74	---	NR	NR	20-40
1975-77	Eng. Dyn.	5	25	20-40

NOTES:

NR - No Requirement

GVW - Gross Vehicle Weight

a/ - HEW engine dynamometer test cycle (steady 2000 rpm, various loads).

b/ - Concentrations are expressed on a volume portion basis through 1974, parts per million (ppm) or volume percent. After 1974 a mass basis of grams per brake horsepower-hour is used.

c/ - Evaporative control requirements may possibly be delayed until MY 1975.

d/ - EMA engine dynamometer test cycle (various stabilized speeds and loads.

e/ - HEW engine dynamometer test - acceleration and lugging modes.

* EPA announced on February 11, 1972 that the 1973 heavy duty vehicle standards proposed on October 5, 1971 were being withdrawn and that new standards would be imposed for the 1974 model year instead. There was insufficient time to change this report to reflect either this new effective date or likely changes in the technical nature of the control requirements assumed in the table.

TABLE A-4. MOTOR VEHICLE PRODUCTION
(Domestic Production Plus Net Imports)

Calendar Year*	Numbers of Vehicles (Millions) Autos	L.D. Trucks	H.D. Trucks & Buses	Total
1967	8.1	1.0	0.6	9.7
1968	10.0	1.1	0.8	11.9
1969	9.7	1.1	0.8	11.6
1970	10.0	1.2	0.8	12.0
1971	10.0	1.2	0.8	12.0
1972	10.1	1.2	0.9	12.2
1973	10.2	1.3	0.9	12.4
1974	10.4	1.4	0.9	12.7
1975	10.7	1.4	0.9	13.0
1976	10.9	1.4	0.9	13.2
1977	11.2	1.4	0.9	13.5

* Reported numbers through 1968, estimated thereafter. Source: U.S. Department of Transportation, Federal Highway Administration, Bureau of Public Roads, with light duty truck numbers estimated from total truck and bus numbers.

TABLE A-5. - CONTROL TECHNIQUES AND ESTIMATED INVESTMENT COSTS FOR MOBILE SOURCE EMISSION CONTROLS 1967-1977

Model Year	Autos and Light Duty Trucks Typical Changes or Controls Added	Additional Cost Per New Vehicle (Dollars)	Total Cost Per Vehicle (Cumulative) (Dollars)	Emissions Per Vehicle as Percent of 1967 Vehicle Level HC	CO	NO_x
1967	None	0.00	0.00	100	100	100
1968-1969	Closed PCV system, carburetor changes, ignition timing changes, inlet air temperature control	5.40	5.40	53	45	111
1970	Additional carburetor changes, idle control solenoid, ignition timing changes	7.40	12.80	40	32	85
1971	Evaporative emission control, improved idle control solenoid with overheat protection (including transmission spark control), low compression ratios, additional carburetor changes	19.70*	32.50*	25	32	85
1972	Valve and valve seat changes for unleaded gasoline	2.00	34.50	20	28	69
1973-1974	Exhaust gas recirculation for NO_x control, speed controlled spark timing	48.00	82.50	20	28	42

* above the cost of controls or simpler system replaced

TABLE A-5. - CONTROL TECHNIQUES AND ESTIMATED INVESTMENT COSTS FOR MOBILE SOURCE EMISSION CONTROLS 1967-1977

Model Year		Autos and Light Duty Trucks Typical Changes or Controls Added	Additional Cost Per New Vehicle (Dollars)	Total Cost Per Vehicle (Cumulative) (Dollars)	Emissions Per Vehicle as Percent of 1967 Vehicle Level HC	CO	NO_x
1975	Alternative 1	Catalytic oxidation of HC and CO (includes long-life exhaust system), unitized ignition systems for 50,000 mile service-free performance, air injection for catalytic unit	163.50	246.00	12	16	42
1976-1977	Alternative 1	Dual catalyst units for HC, CO, and NO_x; or tandem NO_x and CO-HC catalytic units; modified manifold reactors to reduce catalyst load	105.00*	351.00*	3	3	6
		Cumulative 1974		82.00			
1975	Alternative 2	Extremely lean fuel mixtures (unitized electronic ignition with electronic control of spark timing), electromechanical fuel injection, special valves and intake design	125.00	207.00	12	16	42
1976-1977	Alternative 2	Low temperature NO_x decomposition catalyst unit	85.00*	292.00*	3	3	6
		Cumulative 1974		82.00.			
1975	Alternative 3	Catalytic oxidation of exhaust HC and CO, air injection to assist catalytic unit	133.00	215.00	12	16	42
1976-1977	Alternative 3	Exhaust gas recirculation increased to maximum for NO_x control, Modulation of recirculation	14.00*	229.00*	3	3	6

* above the cost of controls or simpler system replaced

TABLE A-6. - GROWTH OF VEHICLE POPULATION 1967-77

Fiscal Year	Millions of Vehicles					Percent Controlled		
	Gasoline-Powered			Diesel-Powered		Gasoline		Diesel
	Autos and Light Duty Trucks	Heavy Duty Trucks	Buses	Heavy Duty Trucks	Buses	Autos and Light Duty Trucks	Trucks and Buses	Trucks and Buses
1967	81.8	5.6	0.28	0.46	0.06	---	---	---
1968	84.6	6.0	0.29	0.50	0.06	9.0	---	---
1969	88.1	6.3	0.30	0.55	0.07	20.5	---	---
1970	91.1	6.6	0.30	0.60	0.07	31.5	7.5	---*
1971	93.8	6.8	0.31	0.65	0.07	42.0	17.0	---
1972	96.8	7.1	0.32	0.70	0.07	52.0	26.0	---
1973	100.1	7.5	0.33	0.77	0.07	61.0	34.5	---
1974	103.5	7.8	0.34	0.84	0.07	69.0	42.5	---
1975	106.9	8.3	0.35	0.91	0.08	76.0	49.5	7.5**
1976	110.5	8.7	0.36	0.99	0.08	82.0	55.5	17.0
1977	114.2	9.1	0.37	1.08	0.08	87.0	61.0	26.0

* Smoke control began in 1970 for diesels. Since some prior model vehicles meet standards with careful operation (and perhaps in-service modifications) percent controlled is applied only to gaseous emissions.

** Assume same age distribution for diesels as for HD gasoline trucks.